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# Implications of Cellular Agriculture for Hospitality and Tourism Management Research: Sustainable Development Goal Perspective

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**Abstract:** The global agricultural sector is facing a disruption driven by economics, emerging technology, and environmental and personal well-being. In particular, advances in cellular biology, along with the emergence of novel production techniques such as precision fermentation, are making the mass-cultivation of alternative proteins in vitro for human consumption an economically plausible proposition. Along with technical and ethical questions, for example on the choice of growth medium or policy implications, the prospect of a decentralised, cultured protein supply chain opens up interesting avenues of future research for hospitality and tourism management. How will hospitality and tourism stakeholders react when new technologies give rise to food service and food tourism that is less reliant on conventional animal husbandry and where properties such as taste, texture, mouthfeel, or tolerability can be cultivated from the molecule-up? Using United Nations' Sustainable Development Goals as a backdrop, this conceptual viewpoint article adopts an applied integrative review methodology to discuss megatrends driving the adoption of a cellular agriculture -based food production system, and puts forward an agenda for future research into cellular agriculture in the context of hospitality and tourism management.

**Keywords**: cellular agriculture, cultured protein, hospitality industry, tourism, management, food, food tourism, SDG, applied integrative review

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## Introduction

Our relationship with food has grown complicated over the last few decades (Yoo, 2015), particularly in post-industrialised nations (National Research Council, 2015). Rather than what we eat, the focus is increasingly on how well our digestive system can process a specific type of protein (e.g. gluten) (Hadjivassiliou et al., 2010) or what ecological impacts (e.g. carbon footprint) our food choices have (Smil, 2013). The convergence of ever cheaper, more powerful technology brings new affordances to conventional food production to address both personal and environmental issues at scale (Eisen, 2018). In particular, commentators, investors, and researchers argue that the way animal protein is traditionally mass produced is set to change in the next few decades due to advances in cellular agriculture (Tubb & Seba, 2019; Bryant, 2020; Blaustein-Rejto & Smith, 2021).

In the hospitality and tourism industry, food plays an important role in creating memorable experiences and a sense of belonging (Boyd, 2015; Yoo, 2015; Davis et al., 2018). Food connects people on local, regional and national levels, forming a key part of the cultural identity of destinations and therefore influencing destination marketing and management decisions (Jiménez-Beltrán et al., 2016; Ellis et al., 2018). Food-related

tourism, defined by the United Nations (2021) as a "type of tourism activity which is characterised by the visitor's experience linked with food and related products and activities while travelling", is also big business, whereby literature has identified food as a major contributor to regional economic development (Du Rand & Heath, 2006; Hall & Gössling, 2016). While playing an important socio-economic role, at the same time, food, particularly different types of meat, has also been identified as a major contributor to the hospitality and tourism sectors' growing greenhouse gas emissions (Gössling et al., 2011; Filimonau & De Coteau, 2019; Tuomisto, 2019). However, despite the important role of food in hospitality and tourism management literature and practice, extant research has so far largely ignored the practical and theoretical implications of emerging food production techniques, most notably cellular agriculture -based technologies which allow animal protein to be cultivated in vitro.

To that end, this conceptual viewpoint article addresses this gap in current knowledge by adopting an applied integrative review methodology to shed light on technologies posing to disrupt traditional animal protein supply chain management. In doing so, the paper contributes to the field of hospitality and tourism management by identifying avenues for future research on food service and food tourism that is less dependent on traditional means of protein production, i.e. conventional animal husbandry. In particular, the paper highlights an important potential contribution from hospitality and tourism researchers by discussing cellular agriculture against the backdrop of United Nations' Sustainable Development Goals (SDGs). Advocating for shared prosperity for people and the planet, the UN SDGs provide a commonly agreed upon blueprint for nations to improve health and education, reduce inequality, and spur economic growth all the while mitigating the harmful effects of climate change (United Nations, 2015). Emerging food production techniques, most notably culturing animal protein through means of cellular agriculture, presents an important opportunity to leverage emerging technological innovation to simultaneously improve the efficiency and decrease the harmful effects of current global food production systems (Mattick et al., 2015; Filcak et al., 2020).

**Methdod**

This conceptual viewpoint article adopts an applied integrative review methodology with the aim to synthesise and assess the literature on an emergent research topic in a way that enables new perspectives to emerge (Torraco, 2005; Snyder, 2019). To that end, streams of literature from three distinct bodies of knowledge: hospitality and tourism management, cellular biology, and sustainable development, are qualitatively weaved together under a common narrative, that is, exploring research priorities of cellular agriculture on hospitality and tourism management theory and practice. The literature was assessed using the following search strategy: 1) hospitality and tourism – hospitality OR tourism AND management AND policy; 2) cellular biology – cultured AND meat OR cellular AND agriculture OR clean AND meat OR fake AND meat OR lean AND meat; 3) sustainable development – SDG OR sustainable AND development AND goal OR sustainability OR sustainable AND hospitality OR tourism. The search was conducted using three digital libraries: Scopus, Web of Science, and Science Direct. The integrative review resulted in three major themes (research areas) consisting of 18 sub-themes (research priorities/specific research questions). Towards the end of the qualitative review process, the resulting themes and sub-themes were compared and contrasted to the United Nations' Sustainable Development Agenda to find parallels in order to better understand how emergent hospitality and tourism management research on cellular agriculture could contribute to the overall narrative on global sustainability.

**Literature review**

The next two sections provide an overview of cellular agriculture with a specific focus on meat substitutes aimed at mass-scale retail consumption by end consumers (i.e. the

so-called consumer packaged goods segment of foodstuff) (Gielens & Steenkamp, 2007). Key developments and companies in cellular agriculture focussed on meat substitutes are briefly reviewed, followed by a synthesis of the key trends driving as well as hindering the uptake of a cellular agriculture -based protein production system.

**Cellular agriculture**

The idea of producing animal protein in a laboratory setting rather than by means of traditional animal husbandry has been around for a few decades (Tuomisto & de Mattos, 2011), and the notion has been referred to by several, mostly interchangeable terms: clean meat, cell-based meat, lab-grown meat, in vitro meat (Rischer et al., 2020). In the early noughties, Edelman et al. (2005) considered the feasibility of producing what they referred to as meat cultured in vitro (that is, outside a biological host). Leveraging cell cultivation and tissue-engineering techniques conventionally used in organ transplantation, they proposed to grow cultured meat products for mass markets. This was seen to address both foodborne illness and zoonotic disease (e.g. due to excess use of antibiotics and growth hormones as well as excess reliance on 'wet markets') and the environmental issues of industrialised animal husbandry (e.g. resource use and pollution) (Datar & Betti, 2011; Wiebers & Feigin, 2020). In 2013 a group of Dutch researchers led by professor Mark Post successfully cultured a beef burger patty from bovine satellite cells for the first time (Post, 2013). Since then many cultured meat products have moved from research labs to commercial settings (Mellon, 2020).

One of the fastest growing companies in the cellular agriculture space in the context of meat substitutes for the consumer-packaged goods sector is Impossible Foods, the startup behind the eponymous "Impossible™ Burger" (Burwood-Taylor, 2019). Through a process called precision fermentation (Tubb & Seba, 2019), the company extracts heme, the molecular compound that gives meat its meaty taste, from soy plant roots and cultivates this at scale in bioreactors using genetically engineered yeast. The end-product is an in vitro produced, plant-based meat substitute that very closely mimics the properties (e.g. taste, structure, mouthfeel) of real meat (Heffernan, 2017). To cope with surging consumer and food service demand, in 2019 Impossible Foods announced global partnerships with Disney, Burger King, and the OSI Group, one of the world's leading suppliers of processed meat products (Lee, 2019).

The commercial success of Impossible™ illustrates the economic potential for building in vitro meat substitutes, regardless of substrate (animal as in Mark Post's demonstration, or plant-based as in Impossible's case), from the molecule up. Indeed, several other companies are leveraging advancements in cellular agriculture to develop novel types of cultivated and plant-based protein foodstuff (Mellon, 2020). In his review of 70+ companies working on producing novel meat substitutes leveraging cellular agriculture, Mellon (2020) highlights for example BlueNalu (a US-based company working on fish meat cultivation), Clara Foods (a US-based company working on cultivating animal-free egg products), as well as Mosa Meat (a Netherlands-based company founded by Mark Post and mainly working on cell-based beef) and Eat Just (a US-based company working on several meat substitute product categories and which most recently gained headlines by bringing the world's first cell-cultured chicken product to market in 2020 in Singapore) (McCormick, 2021).

In addition to the commercial potential of cellular agriculture -based meat substitutes, producing animal protein in vitro appears to be not only cheaper, but also far less resource-intensive than conventional animal husbandry, contributing to less overall costs of production (Tuomisto & de Mattos, 2011; Tuomisto, 2019; Mellon, 2020). This is made possible e.g. by gains in feed efficiency and land use. Keeping livestock requires the mass-production of feed as well as securing enough arable land (Gössling et al., 2011). Tubb and Seba (2019) estimate the feed efficiency of in vitro meat susbtitutes to be up to 25 times higher than that of livestock, while requiring 100 times less land. As in vitro cultivation technologies such as precision fermentation mature and scale up, Tubb and Seba (2019)

estimate cellular agriculture systems as being five times cheaper than means of traditional animal husbandry by 2030.

**Megatrends Driving Adoption**

Besides the economic incentives, there seems to be three key trends driving the adoption of cellular agriculture systems: resilience of the planetary boundaries, an increased interest in personal health and well-being, and the decentralisation for more resilient supply chain management (Bryant, 2020; Rischer et al., 2020; Chiles et al., 2021). In her comprehensive analysis of the global meat market (2020), Emma Gillingham, consumer insights manager at Meat & Livestock Australia, dubs these megatrends as sustainability and the environment, total health and wellbeing, and convenience and connection (Mitchell, 2020).

First, in terms of sustainability, particularly with regards to the environment, studies have identified animal husbandry, particularly industrialised cattle farming, as one of the biggest contributors to global greenhouse gas (GHG) emissions (Gössling et al., 2011; Rischer et al., 2020). The United Nations' Food and Agriculture Organization (FAO) estimates that the livestock sector accounts for ~15% of all man-made GHG emissions, and that on a commodity-basis, beef and dairy account for ~65% (Gerber et al., 2013; FAO, 2018). Population growth combined with increased disposable income and Westernised lifestyles across developing markets are feared to exacerbate this, with the OECD estimating a 13% growth in global meat production by the year 2028, and a projected 45% increase in beef consumption particularly in Asia by 2025 (OECD/FAO, 2016; OECD/FAO, 2019). Noting the harmful impacts of increasing meat consumption on the environment, technology investor and philanthropist Bill Gates recently made headlines by declaring that "all rich countries should move to 100% synthetic beef" (Blaustein-Rejto & Smith, 2021) Given increasing supply and demand, decarbonising the world's meat supply chain simply through more efficient livestock management practices seems unlikely, and thus new approaches, including cellular agriculture, are also needed (Mattick et al., 2015; Filcak et al., 2020).

Second, besides concern for the environment, the uptake of cellular agriculture protein production systems might also be hastened by more individualistic worries, from consumer concerns regarding taste, texture, appearance or price of emerging meat substitutes, to their perceived popularity and market share vis-à-vis traditional meat products (Bryant & Barnett, 2018). As discussed by Bryant and Barnett (2018), one of the key considerations regarding the acceptance of food produced by means of cellular agriculture is the perceived naturalness of products grown in vitro, whereby the current consumer sentiment seems to be that cultured meat is perceived as less natural and by consequence less healthy than conventional meat (Siegrist & Sütterlin, 2017). In terms of global megatrends, this contributes to food-related concern for health and wellbeing, whereby e.g. the exponential increase in digestive disease such as irritable bowel syndrome (IBS) or inflammatory bowel disease (IBD) drives consumers to pay more attention to what they eat and how it affects their bodies (Farthing et al., 2014). Special dietary needs have become better understood (Yeoman & McMahon-Beattie, 2015), as has the connection between the gut and the brain overall (Liang et al., 2018). From a nutritional point of view, the prospect of producing meat in vitro through means of cellular agriculture holds much promise, whereby e.g. optimum nutritional properties and tolerability or even food allergies could be considered and dynamically fine-tuned on a molecular level (Kumar et al., 2021). Overall, the prospect of animal protein that is easier for humans to digest is in tune with the trend of combining food, healthcare, and technology, whereby the notion of a quantified self has started to move from measuring biometrics to optimizing food intake (Ruckstein & Pantzar, 2017).

Third, the uptake of in vitro animal protein production systems might also be accelerated by disturbances in the global protein supply chain, whereby the interconnectivity of food production systems, and disturbances therewith, may impact the availability of

foodstuff such as animal protein (Ijaz et al., 2021). The last few decades have witnessed several outbreaks of enteric and transboundary diseases associated with meat production and handling, such as the bovine spongiform encephalopathy (BSE), the avian influenza, and the African swine fewer (Centers for Disease Control and Prevention, 2017). For example, the African swine fever has in recent years continued to lay waste to global pork supply (Normile, 2019), with the World Organization for Animal Health (2020) warning of a global crisis if the outbreak is not hastily contained. Not only has COVID-19 exacerbated previous supply chain issues (OIE and FAO, 2020), it also presents another viral animal protein supply chain disruptor, with companies such as McDonald's rationing meat supply and warning of global shortages (Kelso, 2020). Given the vulnerability of just-in-time supply chain management systems in the face of global disturbances, the world post-COVID-19 will likely see an increased interest in the localization of supply chain management (Alicke et al., 2021), including protein production and purchasing, due to issues related to workforce (e.g. labour shortage, shutdowns of meat packing facilities) as well as impacts of lockdown conditions and social distancing measures (e.g. restrictions on movement) (Ijaz et al., 2021). As the micro-brewery scene that emerged en masse in the 2010s, the popularisation of cellular agriculture protein production systems might see the rise of micro-precision meat fermentation plants in the 2020s as demand for supply chain resiliency grows and the price of adopting the technology comes down (van der Weele & Tramper, 2014; Tubb & Seba, 2019).

Despite increased interest and investment, there are several challenges that might hinder the uptake of cellular agriculture -based protein production system. These include, inter alia, pushback from traditional agribusiness, regulation around food safety, ethics, and customer acceptance (Bryant & Barnett, 2018 Filcak et al., 2020). It is also important to acknowledge that industrial animal husbandry, despite its drawbacks (e.g. inefficiency of feed and land use and environmental toll), plays a key role in global and regional economic development. This is evident in the United Nations' Sustainable Development Goals, e.g. Development Goal 1, which calls for the reduction of poverty, as well as Development Goal 2 which is aimed at combating famine and malnutrition (United Nations, 2015; FAO, 2019). For example, Brazil derives roughly 21% of its gross domestic product (GDP) from agriculture, of which 7% is from keeping livestock (Tubb & Seba, 2019). Any systems-level change in global protein supply chain management needs to be accompanied with appropriate legislative and policy frameworks to ensure that benefits are equally distributed and a sustainable future food ecosystem is achieved (Rischer et al., 2020).

**Findings and Discussion**

The move away from conventional animal husbandry towards alternative protein production systems centred around cellular agriculture opens several avenues for future research across disciplines, including in hospitality and tourism management. Studies in the fields of food policy and behavioural psychology have already started to explore consumer attitudes towards and awareness and acceptance of alternative meat products (c.f. Mancini & Antonioli, 2019; Van Loo et al., 2020; Bryant & Sanctorum, 2021). Considering the high relevance of food and food production and service systems to hospitality and tourism theory and practice (e.g. increasingly health- or environmentally-conscious tourists and service employees; food/culinary tourism), it is critical to focus research on cellular agriculture protein production and its implications on key stakeholders in hospitality and tourism management

Drawing on three distinct bodies of knowledge: hospitality and tourism management, cellular biology, and sustainable development, this applied integrative review finds three major themes (research areas) consisting of 18 sub-themes (research priorities/specific research questions). The three major themes are: 1) New Service Offerings, Skills and Education 2) Health and Well-being, and 3) Lab-to-Table Food Production Systems.

First, in terms of New Service Offerings, Skills and Education, future research should explore when and how hospitality and tourism stakeholders can start embracing the new production techniques such as precision fermentation (Tubb & Seba, 2019), and which types of products will benefit the sector the most, e.g. in terms of what products should be first substituted with new products, or which elements, e.g. taste, mouthfeel, texture, or tolerability should be prioritised in new product development to drive consumer acceptance (Bryant & Barnett, 2018; Mancini & Antonioli, 2019). Further, as desired properties of food can increasingly be built in from the molecule up (Kumar et al., 2021), it is important to explore the implications this poses on skills requirements and education in the sector (i.e. employees; secondary and tertiary education), tourism and hospitality service offerings (e.g. menu profiling, new service concepts, changes to food tourism), and how consumers will react to them. In terms of the SDGs (United Nations, 2015), these research priorities resonate particularly well with SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (see Table 1).

Second, in terms of Health and Well-being, it is critical to explore whether consumer awareness, attitudes and behaviour towards alternative protein products differ at home and in different hospitality and tourism service consumption contexts (e.g. à la carte restaurants, take away, leisure or business travel) as well as across culture, personal characteristics, and other consumption contexts, e.g. consideration for consumers' own health and well-being and the impacts cellular agriculture might have on these (Bryant & Barnett, 2018; Ellis et al., 2018). Future research should also focus on the influence of environmental considerations on consumers' relationship with food in general and their decision-making in relation to the consumption of tourism and hospitality services (Gössling et al., 2011; Tuomisto & de Mattos, 2011). In terms of the SDGs (United Nations, 2015), these research priorities resonate particularly well with SDG 3 (Good Health and Well-being), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (see Table 1).

Third, complementing research on the 'farm-to-fork' movement, that is, the comprehensive view of the food supply chain as constitutive of food production, food processing and distribution, food consumption, and food loss and food waste management systems (Purnhagen et al., 2021), in light of the developments in cellular agriculture, more research should address issues related to the development, structures, security, and the sustainability of what we dub hospitality and tourism "Lab-to-Table Food Production Systems" (Kumar et al., 2021). Moreover, future research should also investigate the role hospitality and tourism plays as an industry in the uptake of pro-sustainable procurement practices more broadly, including ensuring legislation is put in place to help reduce the carbon footprint of global protein supply chains (Chiles et al., 2021; Ijaz et al., 2021). In terms of the SDGs (United Nations, 2015), these research priorities resonate particularly well with SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (see Table 1).

Drawing on the concept of sustainability transitions (Markard et al., 2012) and following previous research on emerging technology and its implications for sustainable development in the context of hospitality and tourism (cf. Tuomi et al., 2020), Table 1 contrasts the research directions discussed here with the United Nations' Sustainable Development Goals (United Nations, 2015), identifying key research priorities and providing example research questions and preliminary inspiration for bodies of literature that could be used as an initial starting point for empirical enquiries and theory development into cellular agriculture protein production systems as they relate to hospitality and tourism management research.

Table 1.

| Thematic Area | Supporting Literature | SDG | Example Research Questions for Hospitality and Tourism Management |
|---|---|---|---|
| New Service Offerings, Skills and Education | Yeoman & McMahon-Beattie, 2015; Hall & Gössling, 2016; Bryant & Barnett, 2018; Ellis et al., 2018; Jiménez-Beltrán & López-Guzmán, 2018; Mancini & Antonioli, 2019; Filcak, Považan & Viaud, 2020; Bryant & Sanctorum, 2021 | • SDG9, SDG13<br>• SDG8<br>• SDG4, SDG8<br>• SDG4<br>• SDG12<br>• SDG9, SDG12 | • Which cellular agriculture products would benefit the tourism and hospitality sectors the most?<br>• What are the implications of cellular agriculture to menu development and flavour profiling in hospitality settings?<br>• How might job profiles and skills requirements of tourism and hospitality employees shift as a result of cellular agriculture?<br>• How should the shift to cellular agriculture -based protein production be included in hospitality and tourism curricula?<br>• To what degree could cellular agriculture help reduce the carbon footprint of the tourism and hospitality sector?<br>• How might food tourism national strategies differ in terms of adopting cellular agriculture systems across the world? How should DMOs react? |
| Health and Well-being | Gielens & Steenkamp, 2007; Mattick, Landis & Allenby, 2015; Yeoman & McMahon-Beattie, 2015; Siegrist & Sütterlin, 2017; Bryant & Barnett, 2018; Mancini & Antonioli, 2019; Tuomi et al., 2020; Bryant & Sanctorum, 2021 | • SDG3<br>• SDG3, SDG4, SDG9<br>• SDG3, SDG12<br>• SDG3, SDG9, SDG13 | • How can cellular agriculture help reduce hunger and malnutrition at destinations and local communities?<br>• How will customers or food tourists react to cellular agriculture -based food products on the menu? What sort of concerns e.g. regarding safety, naturalness or locality might arise?<br>• How will attitude towards and acceptance of cellular agriculture differ depending on tourism and hospitality consumption context?<br>• What is the relative importance of e.g. cost, nutrition, taste, tolerability, or environmental impact driving tourist decision-making? |
| Lab-to-Table Food Production Systems | Du Rand & Heath, 2006; Van der Weele & Tramper, 2014; Mattick, Landis & Allenby, 2015; Yeoman & McMahon-Beattie, | • SDG8, SDG9, SDG11, SDG13 | • How to support the uptake of specific technologies and approaches related to cellular agriculture, e.g. precision fermentation, in hospitality and tourism companies? |

| | | | |
|---|---|---|---|
| | 2015; Chiles et al., 2021; Ijaz et al., 2021; Kumar et al., 2021; Purnhagen et al., 2021 | • SDG4, SDG8, SDG9 | • How does hospitality and tourism stakeholders' perception of meat change when protein supply chains are increasingly decentralised and decarbonised? |
| | | • SDG4, SDG8, SDG9, SDG11, SDG13 | • What should different members of the food production chain (e.g. animal husbandry, logistics, processing, restaurants, wholesale) know about cellular agriculture -based protein production, and how should they prepare for the technology? How can they play a role in the market transformation? |
| | | • SDG9, SDG11, SDG12 | • How does the lab-to-table food production system differ from previous conceptualisations of farm-to-fork? |
| | | • SDG12, SDG13 | • How should current food-related regulatory frameworks be reviewed in light of cellular agriculture? |

SDG3: Good Health and Well-being. SDG4: Quality Education. SDG8: Decent Work and Economic Growth. SDG9: Industry, Innovation and Infrastructure. SDG11: Sustainable Cities and Communities. SDG12: Responsible Production and Consumption. SDG13: Climate Action.

## Conclusion

Developments in cellular agriculture pose to disrupt the way food, most notably animal protein, is produced and procured (Filcak et al., 2020). This is bound to have knock-on effects on how food is served and consumed (Yeoman & McMahon-Beattie, 2015; Bryant & Barnett, 2018). Given the significant role food plays in hospitality and tourism contexts (Davis et al., 2018), exploring the ways in which novel food production systems, e.g. a transition from traditional animal husbandry to producing meat in vitro, transform hospitality and tourism supply chains, production systems, employment and education, as well as consumer outcomes, becomes imperative. To that end, a research agenda consisting of three major themes (research areas) and 18 sub-themes (research priorities/specific research questions) are put forward. As technologies that only half a decade ago seemed science fiction (Yeoman & McMahon-Beattie, 2015) start to come of age, these research directions map out potential contributions from hospitality and tourism scholars to produce knowledge and guide the sustainable applications of emerging food technology in their sector.

In addition to the overall research priorities discussed herewith, future work should aim to assess the relative importance of these research priorities in the short- to long-term future. Which research questions need to be addressed first and which can wait a bit longer for developments in cellular agriculture to play out? Given the potentially large-scale disruption cellular agriculture is posed to bring to global food production systems (Tuomisto, 2019), any such assessment should prioritise research which hastens rather than hinders the sustainability transition.

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